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HOW CAN R&D LEADTIME BE REDUCED?

By

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US Army War College
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TABLE OF CONTENTS

	Page
LIST OF CHARTS	iii
SUMMARY	iv
CHAPTER 1. INTRODUCTION	1
2. RESEARCH AND DEVELOPMENT ENVIRONMENT	6
General	6
Management system	7
Budgeting and programing	11
Contracting	18
Requirements	21
3. MATERIEL LIFE CYCLE	26
General	26
Concept phase	26
Definition phase	29
Development phase	32
Production phase	34
Operational phase	35
Disposal phase	36
Phase relationship	36
Milestones	39
Configuration management	42
4. ANALYSIS	43
General	43
Review of regulations	43
Requirements	45
Project reorientation	48
Testing	50
Case study of selected projects	51
5. CONCLUSIONS AND RECOMMENDATIONS	61
BIBLIOGRAPHY	63

LIST OF CHARTS

		Page
CHART 1.	R&D command and policy channels	8
2.	The program structure	14
3.	Army R&D program and budget cycle for FY 1967	15
4.	Life cycle spectrum phases	27
5.	Phase relationship	38
6.	Relationship of life cycle to combat developments program	40
7.	Case study milestone analysis	54-55

SUMMARY

Leadtime, measured from the time that a concept is proven technically feasible until developed and produced as a system for operations in the field, is a matter of vital interest to all concerned with maintaining and equipping the Army. The country that can rapidly convert technological advances into superior weapons and equipment systems ahead of its competitors will have a marked advantage.

The leadtime goal of 8 years is believed to be a valid goal for which all production and developing agencies should strive to achieve. This time period permits 2 years in the definition phase to select the best technical approach, perform tradeoff and cost/effectiveness studies, program and budget for the necessary funds, prepare the necessary requirements documents, formulate the master plans for development and production, and obtain authority to proceed with development. Four years is allotted to the actual development phase for design, prototype production, and testing for type classification. The final 2 years are reserved for producing the system in quantity for operational use.

This paper examines the research and development environment in chapter 2 to highlight such key controlling factors as management, budgeting and programing, contracting, and requirements documentation. In chapter 3 the materiel life cycle is described to illustrate the materiel acquisition process. It is composed of six phases: concept; definition; development; production; operational; and disposal. Each of the phases is descriptive of the work being performed in it. Only the definition, development, and production phases have appreciative impact on the leadtime goal.

Current management, requirements, testing, and development procedures are analyzed to determine where they can be streamlined and improved to shorten the leadtime. Selected project histories are studied to test the validity of these improvements. Finally, certain conclusions and recommendations are made that if adapted may lead the Army towards an 8 year leadtime objective.

CHAPTER 1

INTRODUCTION

The rapid strides and advances made in science and technology since the end of World War II have accelerated the development of new complex weapon and equipment systems. These developments have brought to light many problems in the management of research, development, procurement, and logistics support. These problems involve rapid integration of advancing technology into our weapons and equipment systems; choice of alternative systems to meet new threats; proliferation of industrial capability; and development of new procedures to control cost, performance, and time schedules in the acquisition and support of these systems.[1]

In the past, large scale development and production programs were undertaken before requirements were clearly defined and before it had been clearly determined that the technology necessary for the development was clearly shown. This inadequate prior planning led to large cost overruns and schedule slippages. These overruns and slippages had an adverse impact on existing programs, since many projects were eliminated or reduced in scope to pay for prior years' mistakes.[2]

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[1]James W. Roach, "Management Trends in Defense Development and Production," News Release, Office of the Assistant Secretary of Defense (Public Affairs), 31 Mar. 1965, p. 1.

[2]*Ibid.*

These expensive errors in resource management for research and development were occurring at the time when the typical development project promised only a nominal improvement in our total military capability. If these projects could have added a unique new dimension to our military capability, such as the atomic bomb or the intercontinental ballistic missile, then great costs and risks would have been justified. This type of development today is considered rare.[3]

Within the Army there have been many studies conducted during recent years to improve the weapons development and acquisition process. Most of these studies have been oriented towards reducing leadtime and cost. Leadtime became a popular topic in the late 1950's, when it became obvious that the Russians had gained an advantage over the United States in the development of large rocket propulsion systems and their application to vehicles capable of space exploration and delivery of intercontinental missiles. If the Russians were ahead in these fields, one wonders in how many other areas they also are superior. Studies on Soviet leadtime, for the most part, indicate that the USSR leadtime experience is about one-half that of the United States.[4] If true, this is a situation that the United States cannot long endure and maintain its leadership position.

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[3] Ibid., p. 6.

[4] US Army Materiel Command Board, Control of Lead Time, Project AMCB 2-64, 30 Jun. 1965, p. 1 (referred to hereafter as AMCB 2-64). FOR OFFICIAL USE ONLY.

The average total leadtime within the Army in 1962 was determined by the Materiel Requirements Review Committee Study (Gen Fischer chairman) to be 10 years and 10 months. Leadtime for this study included the progression of stages of an item which begins with the first proposal to or by the military that an idea be given military application through establishment of a military requirement, feasibility study, establishment of a project, research, development, testing, type classification, production, placement in the inventory, and issue to troops in quantity sufficient to equip the active Army.[5] This study was a major step forward in the Army acquisition process, in that it accomplished two important tasks: it made a most comprehensive and penetrating analysis of leadtime experience within the technical services; and, it highlighted a number of deficiencies that should be corrected.

Three years later, in 1965, another comprehensive study was made by the U.S. Army Materiel Command (AMC) to identify and critically analyze chronological steps in the materiel development and acquisition process, and to determine where and how control of leadtime could be effected. The study and its recommendations are in the process of being implemented within the Army Materiel Command. This study, based on a case study of some eight representative projects, came up with a total average leadtime of

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[5]US Dept of the Army, Military Requirements Review Committee, Lead Time Study Vol. I (U) and Case Studies Vol. II (U), Vol. 1, p. 2, Vol. I CONFIDENTIAL, Vol. II SECRET, Aug. 1961.

7 years and 2 months.[6] The MRRC study and the AMC study leadtimes are not comparable since leadtime was defined somewhat differently. The later study is important in that it highlighted areas which were fruitful for control of leadtime, and it was a test of how well the previous study recommendations were carried out by AMC.

Another study especially worthy of note was published in June 1965 by AMC. This study provided a panoramic portrayal of the complete Army materiel life cycle to assist all AMC personnel in obtaining an understanding and appreciation of their contribution and its correlation within the overall weapons acquisition process. The study established a life cycle model to identify milestones, decision points, and responsible authorities common to most variations of the research and development cycle.[7] This model has been approved as the guide to be utilized by AMC personnel in planning, scheduling, and managing new and existing R&D projects.

The stated leadtime objective of the Army is 4 years or less from initiation of development effort to type classification of the item or system as standard.[8] This objective has been generally recognized as being an acceptable goal but has yet to be reached

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[6]AMCB 2-64, op. cit., p. 15.

[7]US Army Materiel Command, Guide to Life Cycle of US Army Materiel, Army Programs AMCP 11-2, p. i, Jun. 1965.

[8]US Dept of the Army, Army Regulations 705-5, p. 2, 14 Jan. 1963.

within the Army except in isolated instances. Minimization of leadtime is a challenge to which everyone involved in the military weapons systems acquisition process must give serious consideration. Any reduction in leadtime may mean cost savings and a more effective combat force for the Army.

The purpose of this thesis is to examine critically the R&D cycle developed by the U.S. Army Materiel Command in 1965 and to see how leadtime can be reduced from the birth of a concept to actual production and distribution. Primary emphasis will be placed on actual development, design, and test of materiel with less attention being given to actions prior to project initiation and subsequent to type classification. To properly set the stage it is necessary to describe briefly the environment in which research and development is conducted and then to analyze the cycle to see what areas are most amenable to reducing leadtime. To test the feasibility of the leadtime reductions, selected case histories compiled by the AMC Board and Headquarters AMC are used to verify the conclusions reached.

CHAPTER 2

RESEARCH AND DEVELOPMENT ENVIRONMENT

GENERAL

Materiel research and development within The Department of Defense (DOD) is highly centralized and controlled at the highest levels. Since the creation of DOD, the Joint Chiefs of Staff (JCS), and high level counterparts of the DA staff, a detailed review procedure has been established for all research and development projects. This procedure is such that no master review by any of the higher echelons is sufficient to provide decisions on all phases of program, budget, fiscal, apportionment of funds, research, development, and production matters. Hence, many manhours are being spent by top managers in reviews and rejustifications at each echelon, with each level of management being able to say "no" to a program but not being held responsible for the actions caused by this disapproval.[1] As a result, before examining the R&D cycle it is necessary to examine certain key aspects of the environment that materially affect the materiel development and production process.

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[1]US Army Materiel Command Board, Control of Lead Time, Project AMCB 2-64, 30 Jun. 1965, p. 5.

MANAGEMENT SYSTEM

Secretary of Defense, Robert S. McNamara summed up the current DOD management system when he stated:

> The basic objective of the management system we are introducing and trying to operate, is to establish a rational foundation as opposed to an emotional foundation for decisions as to what size force and what type force this country will maintain. This rational structure, this intellectual foundation for determining the military forces we should build and support is something that is laid out on paper. It is laid out first in the form of an analysis of the potential contingency war plans for a variety of situations and, then, a translation of these war plans into military forces. And finally, that force structure must be translated into programs and budgets. . . . Once one has a rational foundation from which to begin, it is relatively easy to decide not to have a particular weapons system, the requirement for which cannot be found in the rationalization of the program.[2]

Overall direction and control of research and development within DOD is vested in the Director of Research and Engineering (DDR&E). Most of the R&D carried on within DOD actually is performed by the separate departments, of which the Army is one. Chart 1 shows the main channels of R&D policy generation, command, and control.[3] For simplicity only the Army organization is shown and other staff agencies are omitted. Similar organizations are set-up in the Navy

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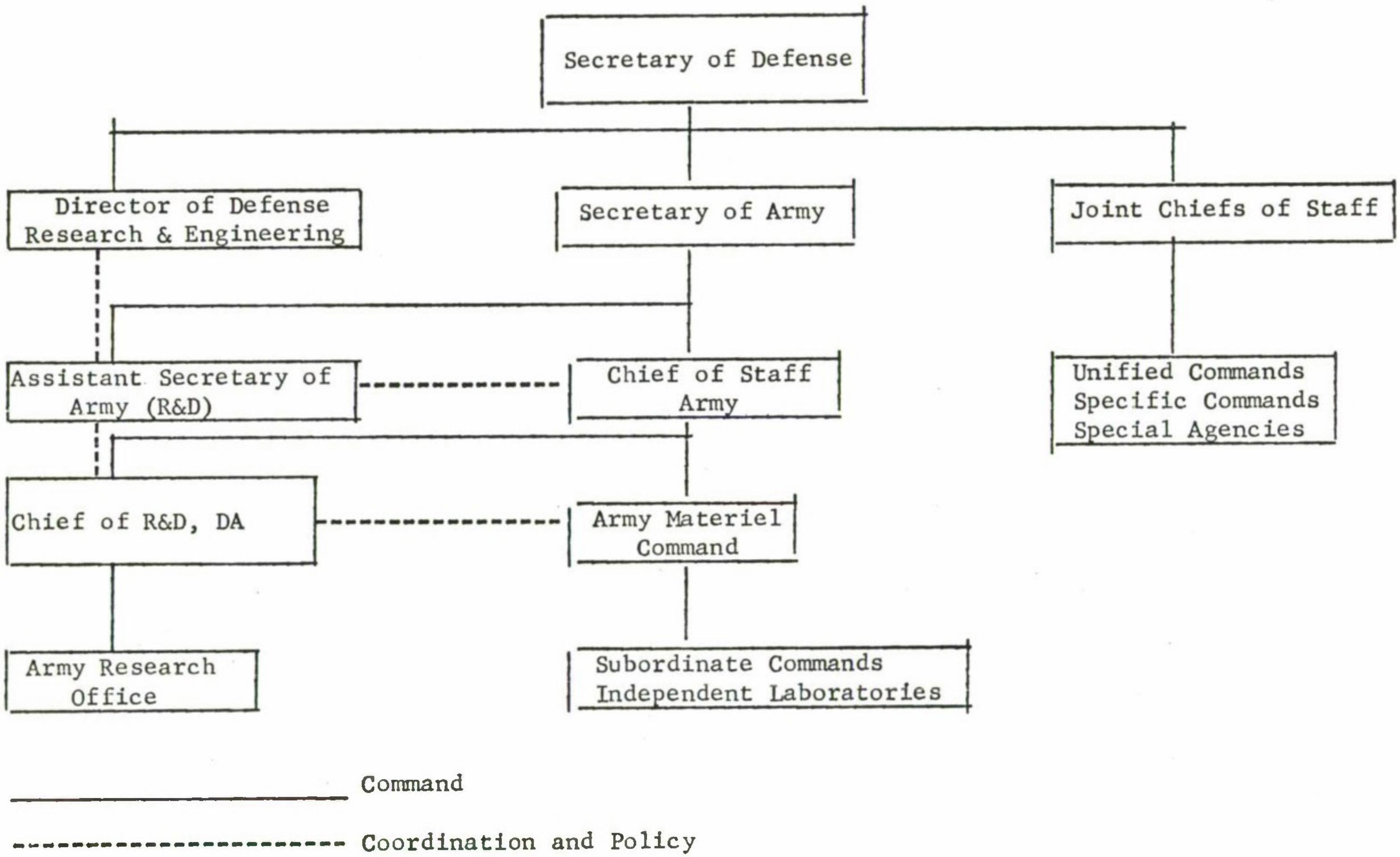
[2]US Congress, House, Committee on Armed Services, United States Defense Policies in 1964, pp. 87-88.

[3]US Dept of Defense, Office of the Director of Defense Research and Engineering, Data Concerning the Management of the Research and Development Program of the Department of Defense, p. 3, Jul. 1965, (referred to hereafter as DDR&E R&D Data).

CHART 1

R&D COMMAND AND POLICY CHANNELS



and the Air Force. Within the Army, other agencies such as the Chief of Engineers, the Surgeon General, and the U.S. Army Security Agency perform R&D, but they have been omitted from the diagram, since they account for only about 5 percent of the Army's R&D.[4] The great bulk of the Army's R&D is vested in the U.S. Army Materiel Command. For that reason, only AMC's management will be discussed.

The AMC system for materiel management is based primarily on centralized control of weapons and equipment systems by commodity groupings. There are three major management systems utilized. They are functional, project, and commodity management.[5]

Functional management is a function-oriented management approach that derives its authority and responsibility from the commander. The functional director is directly responsible to the Commanding General for those related activities assigned to him, i.e., personnel and training, procurement and production, supply, research and development and so on. The functional director has many items or projects to consider and does not focus his attention on a few projects, as do the commodity and project managers. Normally the functional director is not concerned with life cycle materiel management.[6]

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[4]William C. Gribble, AMC's Role in the Evolution of Weapon's Systems, p. 15, 19 Feb. 1964.

[5]US Army Materiel Command, Guide to Life Cycle of U.S. Army Materiel, Army Programs, AMCP 11-2, p. 25, Jun. 1965 (referred to hereafter as AMCP 11-2).

[6]Ibid.

Project management is a technique wherein total responsibility for research, development, production, and fielding of the project managed item is assigned to one individual who is given the necessary authority and resources to accomplish his mission. He has the Commanding General's full line authority over all planning, direction, and control of tasks and associated resources involved in providing the designated system or equipment to using units or for delivery to the intended operational destination.[7] Although the functional director is the activity director for funds and resources, the project manager has complete freedom, subject to restrictions from above, to use the allotted resources as he sees fit. Project managers report directly to the Commanding General or through a designated subordinate commander. Sometimes a project manager may have a commodity manager assisting him at the subordinate command level.

Commodity management is an item-oriented management approach which centers authority and responsibility for a commodity in a single individual at the commodity command level. Commodity management is an approach available to the commander to parallel project management and assist him in maintaining adequate item appraisal and control not otherwise practical through his functional staff or organization.

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[7] Ibid., pp. 25-26.

Commodity managers generally operate offline and do not have directive authority as do the project managers.[8]

Recent trends within AMC indicate that most major projects are project-managed and that more and more projects are being commodity-managed at the subordinate command level.[9] Generally, research and early exploratory development projects are function-managed while item oriented and production projects are usually project-or commodity-managed.

BUDGETING AND PROGRAMING

To understand the basic research and development cycle, one first must understand the budget and programing system used within the DOD. "Military commanders no longer have the final choice of weapons systems for national defense. Weapon system selections are . . . recommended by the military departments and separately staffed within OSD."[10] Prior to establishment of the current programing system, each Department Chief was able to determine almost unhindered, except by Congress how he was to utilize and extend his resources within generalized resource limits. Now, however, the whole of the Defense budget is related to resources and military

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[8] United Research Incorporated, A Study of Commodity Management Within the Army Materiel Command, p. 6 , Feb. 1965.

[9] Frank S. Besson, Jr., "Materiel Support," Army, Vol. 15, Nov. 1965, p. 65.

[10] Perry L. Shuman, "Military Management: A Realistic View," Marine Corps Gazette, Jun. 1964, p. 20.

activity contained within a program identified as the Five Year Force Structure and Financial Program (FYFSFP).

The resource management system of the Army consists of the formalized administrative process of planning, programing, and budgeting. These processes are mutually supporting and closely integrated at the Army General Staff level. Planning and budgeting are somewhat similar, in that they generate supporting documents which are cyclic in development and updating. There is, however, a wide divergence and lack of correlation between preparation and document content of the two processes. Programing is the process that ties together planning and budgeting. Planning is the primary means of announcing strategic concepts and military requirements to accomplish the Army mission. Programing develops a succession of time-phased actions to attain the resources required to implement a plan. Programing involves considerations of cost, feasibility, and effectiveness of alternate courses of action to attain these objective resources. Budgeting relates to individual service planning and programing, in that it provides Congressional and Presidential approval of monies required to implement the approved portions of planning and programing. Therefore, it can be said that the FYFS&FP provides standardized procedures, clearly identifies resources, assigns responsibilities, and prevents constant changes.

The DOD programing system is mission-oriented and is constructed on a 5-year basis--more properly, the current year plus 5 years for

funds, and the current year plus 8 years for forces. This system enables DOD to (1) coordinate long-range and midrange planning and the annual budgetary process; (2) orient top-level planning toward major Defense missions; (3) conduct cost/effectiveness analyses with respect to alternative force structures; (4) relate the impact of resources to the outfit of military systems and materiel; and (5) propose, review, and approve or reject changes in programs at any time.[11]

The programing system organizes all Defense activity into nine DOD wide programs (chart II).[12] Each major program is subdivided into program elements whose mission characteristics are closely related. The comprehensive plan that is the outcome of the programing process is called the FYFS&FP. Included in the RDT&E portion are all program elements of Program VI Research and Development, as well as development, test, and evaluation parts of other than Program VI elements whose systems have been approved for production and deployment.

The detailed development of the program for a particular fiscal year starts some 18 to 20 months prior to the beginning of that fiscal year. Chart III shows the development of the program and budget as it relates to fiscal year (FY) 1967. In October and November of calendar year (CY) 1965, the Army staff provided detailed instructions to the developing agencies in preparation of their submissions of recommended programs.

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[11]DDR&E R&D Data, p. 23.
[12]Ibid., pp. 22-26.

CHART II

THE PROGRAM STRUCTURE

Programs

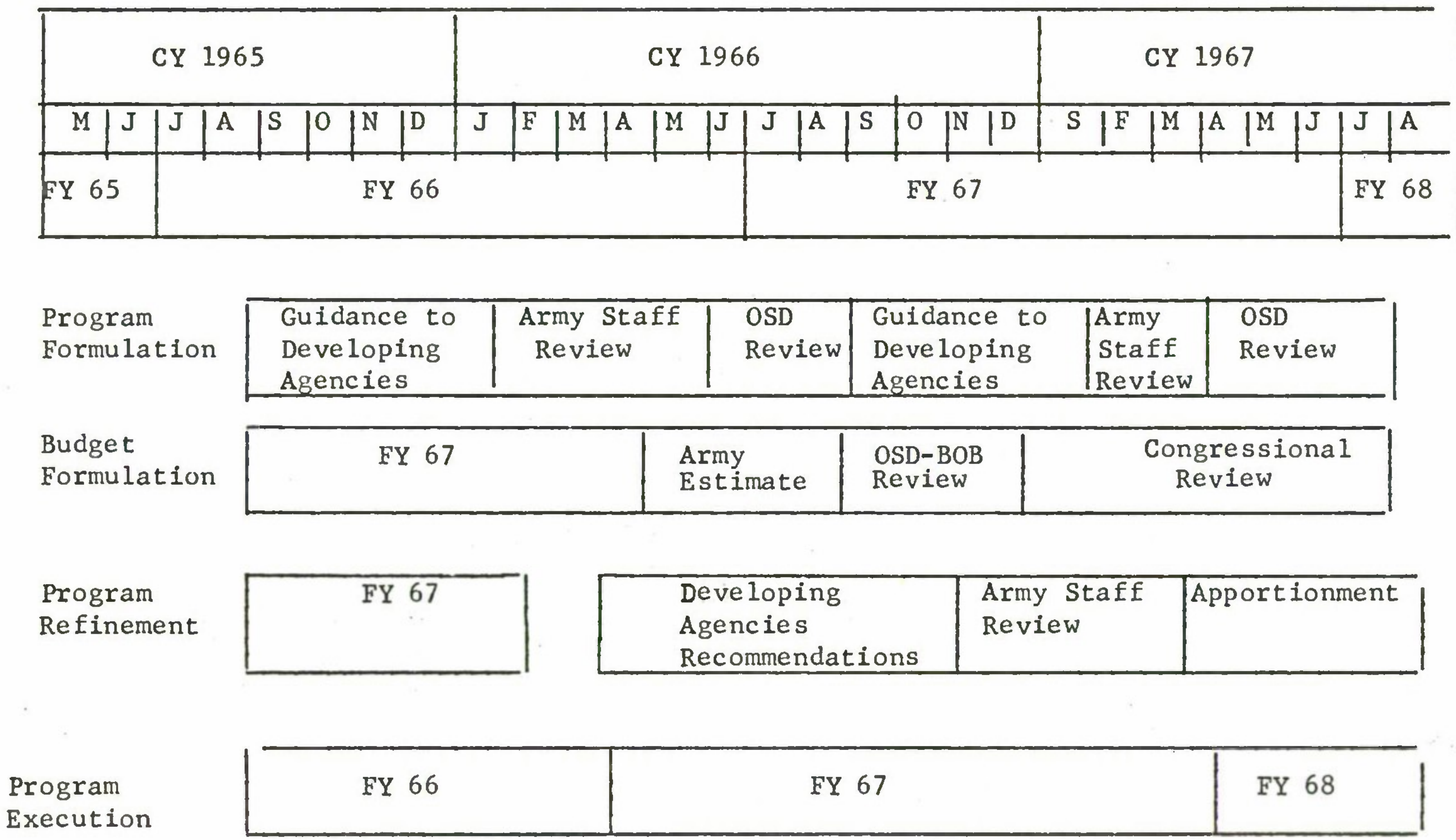
I	Strategic Retaliatory Forces
II	Continental Air and Missile Defense Forces
III	General Purpose Forces
IV	Airlift and Sealift Forces
V	Reserve and Guard Forces
VI	Research and Development
VII	General Support
VIII	Civil Defense
IX	Military Assistance

Program Subdivisions - Research and Development

1. Program - VI
2. Category - Research, Exploratory Development, Advanced Development, Engineering Development, Operational Systems Development, Management and Support
3. Aggregation - Example - Firepower other than missiles contains 1 or more elements
4. Element - Example - main battle tank
5. Project - 1 or more per element
6. Task - Usually 1 or more per project
7. Work Unit - Usually 1 or more per task

CHART III

ARMY R&D PROGRAM AND BUDGET CYCLE FOR FY 1967



At that time broad narrative guidance by various fields of endeavor was provided and funding levels were indicated based on the OSD 5-year program. These funding levels were updated later when the FY 1966 President's Budget was ready for submission to Congress (December 1964). The developing agencies presented their recommendations by late February 1965 in the form of what are called Command Schedules. The schedules concentrate on recommendations for adjustments in the program contained the President's Budget plus the next (target) fiscal year. So in February 1965 Army agencies were concentrating primarily on FY 1966 and FY 1967 and projecting 5 years beyond out to FY 1971. A comprehensive Army staff review of the developing agencies' recommendations was undertaken during early spring of CY 1965. The program was then submitted to OSD in May 1965. At this time, major changes to the OSD approved program were forecast to the Secretary of Defense by memorandum and later followed up by Program Change Proposals (PCP). As the program was then in the final stages of being approved, initial work could be started on preparation of the budget for FY 1967. The budget estimate was developed in light of the approved FYFS&FP and subsequent guidance and was sent to OSD around 1 October 1965. Review by OSD and the Bureau of the Budget (BOB) followed. The estimate was refined and modified as a result. In December 1965 the President's budget was completed and submitted to Congress in January 1966. Obviously considerable time has elapsed since the developing agencies initially recommended the

program (14 months). Hence, the Command Schedule must be updated to keep the program current. Once again the recommendations are reviewed by the Army staff (see program refinement time on chart) to prepare the detailed apportionment request. This request is submitted to OSD for approval. Following passage of the Appropriations Act, the Secretary of Defense allocates funds to the Military Departments. Thus, the FY 1967 program will be reviewed twice in considerable detail prior to its execution--once as the target year and once as the budget year. With each review the other years in the program are considered also. A vertical cut through November-December 1966 will show what the Army will be doing at that time. The Army will be performing the following functions:

1. Formulating guidance to the developing agencies concerning the FY 1969 program.

2. Assisting OSD in its joint review with BOB of the FY 1967 budget.

3. Having the developing agencies submit recommendations refining their FY 1968 program so that the apportionment request can be made.

4. Monitoring the execution of the FY 1967 program.[13]

The programing and budgeting procedures are fixed and unchangeable. Inadequate justification and presentation of

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[13]Raymond B. Marlin, Qualitative Requirements Documentation, pp. 3-5, Mar. 1964.

requirements at any place along the line will defer or delete the project from the RDT&E program.

CONTRACTING

Since a great part of the DOD funds allocated for R&D are spent out-of-house, the procedures used to contract for the necessary work and services must be examined and related to the Research and Development cycle. In certain cases, contract administrative leadtime has materially lengthened the R&D leadtime.

In 1962 the Armed Service Procurement Regulations (ASPR) were modified to emphasize the selection of contract types which provide maximum profit incentive for superior performance. This required a shift away from cost-plus-fixed-fee (CPFF) contracts (38 percent in 1961) to firm fixed price contracts (FFP) and cost-plus-incentive-fee contracts (CPIF).[14]

Sound procurement practice requires a discriminatory choice of the right contract for a particular procurement. The primary factor in determining the right contract for a particular procurement is confidence in the cost estimate, which is dependent on detailed definition of the task involved. As a new development progresses through the various stages of its life cycle, increasing amounts of data become available. Thus, there is a direct relationship among

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[14] James W. Roach, "Management Trends in Defense Development and Production," News Release, Office of the Assistant Secretary of Defense (Public Affairs), 31 Mar. 1965, p. 7.

the program phase, availability of technical data, confidence in the price, and the type of contract best suited to the procurement.

In general, CPFF contracts now are restricted to the Research and Exploratory development categories, where the uncertainties involved on contract performance cannot be estimated with sufficient reasonableness to permit use of any type of fixed price contract. Incentive contracts are used in the advanced development, engineering development, and operational systems development categories of the life cycle. Here, incentives are usually placed on performance, cost, and schedules. Fixed price contracts are desired for production contracts and those development contracts that have well-defined work statements and firm technical data available.[15]

Procurement for materials and services may occur at any time during the life cycle of Army Materiel. To prevent administrative delays, procurement planning must be initiated several months in advance of the time a contract is to be let. In general, the larger the dollar amount of the contract, the longer it takes to award it.[16] Processing times and approvals required must be considered in procurement planning to preclude delaying actions unnecessarily. Experience has shown that it takes about 4 to 5 months to issue a Request for Proposal (RFP); give the contractors

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[15]Harold Brown, "Management of Research and Development," Memorandum for the Assistant Secretaries (Research and Development), 18 Jan. 1963, p. 5.

[16]AMCP 11-2, p. 16.

sufficient time to prepare their proposals; and give the Army time to evaluate them, negotiate, and then obtain approval to award. In R&D procurements it takes 3 to 4 months additional time to obtain Secretarial approval of the Determination and Findings (D&F) for all negotiated procurements over $100,000. This process has to be repeated each fiscal year, since the D&F also is used by DA and OSD as a program control document in addition to being the authorization to procure certain work and services.[17]

The U.S. Air Force's C-5A program is an excellent example of how complex the contract award process can be. The C-5A is the first program in which the total package responsibility authority concept has been tried. The new airplane is supposed to have only a few basic requirements, yet the Request for Proposal (RFP) was over 1,500 pages in length, the technical proposals averaged nearly 60,000 pages, and the cost proposals averaged 7,000 pages. Just to read and evaluate the proposals took 400 Air Force personnel over 5 months. It took over a year of leadtime to prepare the RFP, issue it, allow contractors time to reply, evaluate the replies, negotiate, obtain higher level approval, and then to award the contract.[18] This type of leadtime cannot be tolerated in this age of rapid technological advance.

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[17] Ibid.

[18] Robert H. Charles, Statement of U.S. Air Force Assistant Secretary (Installations and Logistics . . .), pp. 2-3, Sep. 1965.

REQUIREMENTS

Another factor that has a decisive bearing on the R&D cycle is the so called--"requirements merry-go-round."[19] The R&D programs pursued by the Army today are directly related to its roles, missions, and combat objectives. The Army's long-range planning effort is based on a 20-year projection of its needs contained in three main planning documents: the Basic Army Strategic Estimate (BASE); the Army Strategic Plan (ASP); and the Army Force Development Plan (AFDP). Each is arranged in a manner to cover the short, mid, and long-range periods.[20]

During 1965 the Combat Developments Command (CDC) developed a combat developments process designed to facilitate intergration of new or improved doctrine, materiel, and organizations into the Army during a specified time-phased period. This system is directly related to the Army's system of plans as well as AMC's model of its materiel life cycle. The CDC combat developments process was developed independently of AMC's life cycle, and yet both are compatible and necessary ingredients for successful new materiel systems. The CDC's Army Concept programs are correlated with the Army's family of plans. This is especially true of the AFDP. Further, the division of the combat development system into 5-year

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[19]James T. Ramey, "The Requirements Merry-Go-Round: Must Need Precede Development," Bulletin of the Atomic Scientist, Vol. 20, Nov. 1964, p. 12.

[20]Edward Duda, Qualitative Requirements Documentation, p. 1.

increments fits into the pattern of BASE, ASP, and AFDP without any difficulty.

Currently, there are five Army Concept Programs in the CDC Army Concept program: Army 80 (short range program), Army 75 (mid range), Army 85 (long range), Army 80, and Army 90. Each program is designed to cover a 5-year period ending in the fiscal year stated by the last two digits. Thus, Army 75 visualizes an implementation period extending from 1 July 1970 to 1 July 1975. Similar extensions of time are true for the other programs. Each 5 years new programs will be designated as the short, mid, and long range programs. For example, in 1970, Army 75 will be the short-range program; Army 70, the mid range program; and Army 90, the long-range program.

Each of these combat developments concept programs generates requirements that guide AMC in its R&D work. Army 90 includes the studies, experimentation, and all combat developments actions that become the basis for modeling the Army of the future for the time period 20 to 25 years hence.[21]

Thus, the CDC generates requirements for use by AMC and other Army development agencies in their continuing quest to develop new and better equipment. All of AMC's R&D is directly related to approved requirements generated by CDC's combat developments process. To illustrate, Army 90 (also identified as T-25 to T-20 where T-25

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[21]Ben Harrell, "Today's Vision: Tomorrow's Victory," Army, Vol. 15, No. 1965, pp. 66-67.

stands for a target date 25 years to 20 years in the future) generates general objectives as a guide to basic research; Army 85 (T-20 to T-15) generates qualitative materiel development objectives (QMDO's) as a guide to applied research and exploratory development; Army 80 (T-15 to T-10) generates qualitative materiel requirements (QMR's) as a guide to development, test, and evaluation as well as advanced, engineering, and operations system development work; Army 75 (T-10 to T-5) generates tables of organization and equipment (TOE) from which a basis of issue (BOI) may be developed to determine the quantity of materiel that should be purchased; and finally Army 70 (T-5 to T) proof tests the prior planning and revises the equipment, doctrine, TOE's, and so on as necessary. It is during this time that the orderly transition will be made to the new doctrine, materiel and organization.

While the above illustrates a nice orderly transition from concept to reality, "quantum jumps" in technology could cause a rapid change or speed up of the whole concept system. As a result, close coordination is maintained between CDC and AMC to evaluate and moniter R&D at all levels. Advances in the "state-of-the-art" could cause materiel in one time frame to be advanced to another.

In theory QMDO's, Small Development Requirements (SDR's), and QMR's are generated by CDC as a result of its combat development concept process. In practice, however, new requirements documents may be prepared in draft by anyone including operational units, commands, industry, or AMC. QMDO's and QMR's may be initiated as

a result of operational experience, developmental experience, technological breakthroughs, or feedback on deficiencies in existing equipment. In addition, requirements documents may be prepared or changed at any stage or part of the R&D cycle as the situation dictates. The QMDO is associated with new materiel requirements necessitating further research. It normally is prepared some 3 to 8 years prior to the time that firm military characteristics can be stated. QMR's are prepared at the earliest time after the need is recognized and the probable feasibility has been determined.[22] New QMR's and projects initiated as a result thereof will not be approved unless the following requirements have been fulfilled:

1. Primarily engineering rather than experimental effort is required and the technology needed is sufficiently in hand.
2. The mission and performance envelopes are defined.
3. The best technical approaches have been selected.
4. A thorough trade-off analysis has been made.
5. The cost effectiveness of the proposed item has been determined to be favorable in relationship to the cost effectiveness of completing items on a DOD--wide basis.
6. Cost and schedule estimates are credible and acceptable.[23]

The normal processing time to establish QMR's averages from 8 to 18 months. Ideally, the QMR approval date and the initiation date of the new development project should be as close as possible to prevent undue delay in initiating development and to use the latest state-of-the-art advances. To accomplish this objective,

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[22] AMCP 11-2, pp. 28-29.

[23] US Dept of Defense, Initiation of Engineering and Operational Systems Development, Directive 3200.9, p. 4, 1 Jul. 1965.

program scheduling must be initiated some 18 to 20 months in advance of the time funds are estimated as being needed.[24]

SDR's are staffed and approved in a manner similar to QMR's but require less time to prepare and approve. They also require less development time and are limited to projects costing less than $2.5 million. Hence, since they are applicable to only a small portion of the annual R&D budget (0.5 percent in FY 1965) they will not be discussed further.[25]

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[24]AMCP 11-2, op. cit., p. 31.

[25]US Dept of the Army, ad hoc Working Group, Final Report on Materiel Requirements and Development Procedures, 15 Apr. 1965, p. 6 TAB N. FOR OFFICIAL USE ONLY

CHAPTER 3

MATERIEL LIFE CYCLE

GENERAL

The typical materiel life cycle extends 30 years or longer depending on the time allotted to the research phase of the cycle (Chart IV).[1] The materiel cycle includes research, component development, design and development, test, production and distribution to troops in the field, and finally disposal of the item from the Army inventory. AMC has divided the materiel cycle into six logical phases. They are the concept phase, the definition (contract formulation and contract definition) phase, the development phase, the production phase, the operational phase, and the disposal phase. The title of each phase describes the work being done.[2]

CONCEPT PHASE

The concept phase has its beginning in basic research and continues into component development. Projects are justified on broad statements of general objectives outlined in DA guidance documents such as the AFDP, ASP, BASE, the Army Research Plan (ARP) and combat development concept studies. It is during this phase

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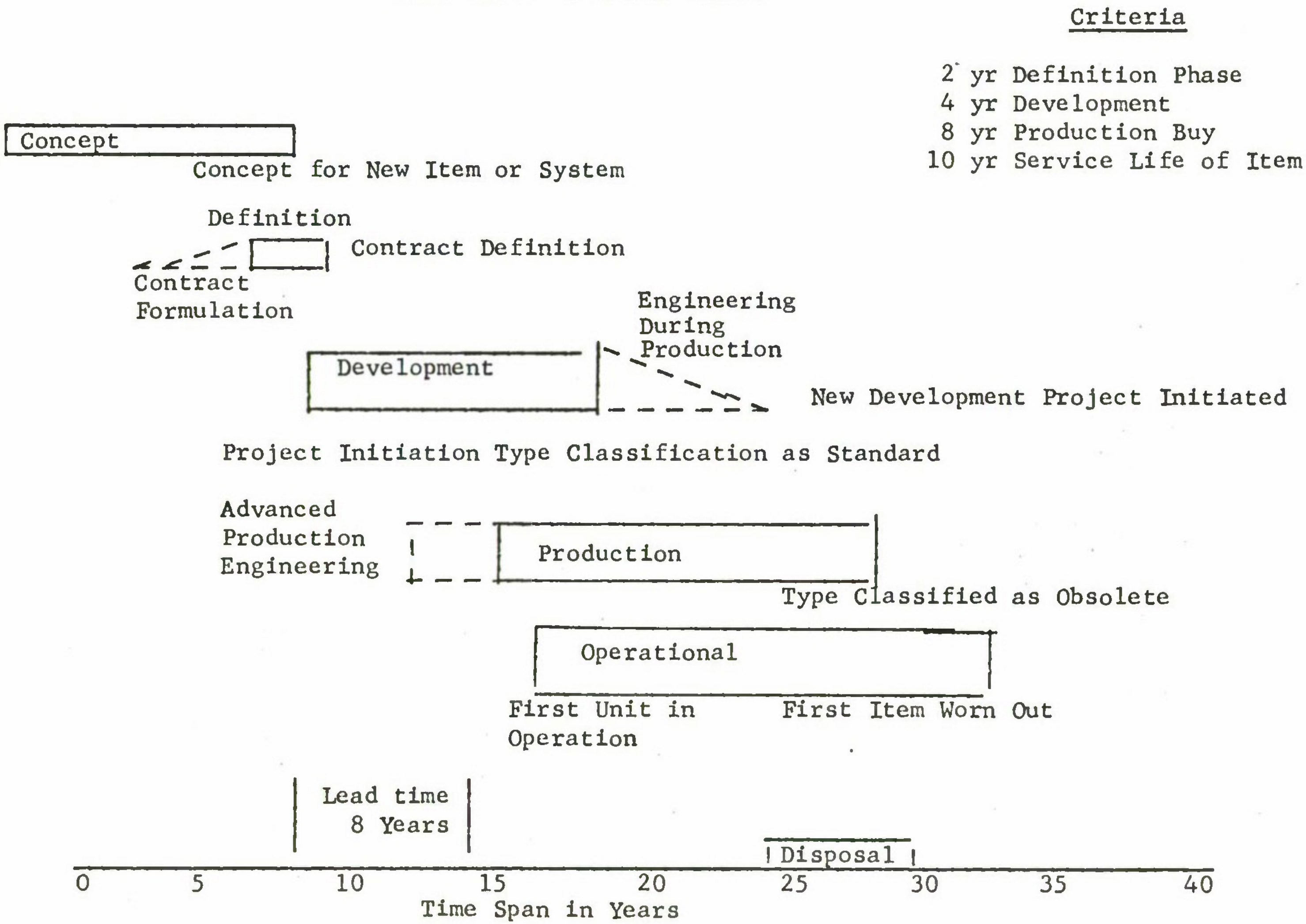
[1]US Army Materiel Command, Guide to Life Cycle of U.S. Army Materiel, Army Programs, AMCP 11-2, pp. 31-3, Jun. 1965, (referred to hereafter as AMCP 11-2).

[2]*Ibid*.

CHART IV

LIFE CYCLE SPECTRUM PHASES



that QMDO's are prepared and issued. A survey made in 1965 showed that 80-85 percent of the concept phase work was justified by one or more QMDO's or other requirements documents.[3] All projects in this phase fall within the research, exploratory, and advanced development categories of program VI Research and Development. This phase may last the 9 years shown on chart IV or may last 20 or more years.[4] It is the phase least susceptable to time phasing, because research cannot be as precisely scheduled as are design, development, and production. The concept phase ends when the concept selection process begins to analyze and study one or more technically feasible solutions or when the feasibility of the QMDO has been determined.

The fundamental purpose of the concept phase is to maintain a broad base in research with which to provide the requisite state-of-the-art and technological base for support of systems development. It is during this time that sufficient cost and technical data are generated on which to base decisions on future development.[5]

Basic and applied research projects in the research and exploratory development categories are managed by higher headquarters on a stable-dollar-level-of-effort basis. They are initiated and justified on the basis of DD Forms 1498 and do not receive individual

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[3]US Dept of the Army, Ad Hoc Working Group, Final Report on Materiel Requirements and Development Procedures, 15 Apr. 1965, p. 2, Tab N (referred to hereafter as Ad Hoc Working Group). FOR OFFICIAL USE ONLY.

[4]*Ibid.*, pp. 1-20 Tab O.

[5]AMCP 11-2, pp. 35-36.

project review at DA and OSD as do all the other projects. Also, they do not need a specific requirements document before they can proceed.[6] Those concept phase projects falling within the advanced development category, however, do require a different kind of documentation. Generally, they are justified on the basis of a QMDO and require a technical development plan (TDP). The projects themselves are reviewed at OSD and DA on a line-item basis.

The U.S. Navy and the U.S. Air Force have advanced development objectives (ADO) to guide their work in the advanced development category. As of now, the Army has no such document and depends on either a QMDO or a QMR, whichever is appropriate. A recent study recommended against the use of another requirements document and recommended the use of a qualitative materiel approach (QMA). The QMA, when attached to a QMDO, would serve the same purpose of an ADO without the necessity of preparing new requirements documents.[7]

DEFINITION PHASE

The definition phase follows the concept phase, proceeds the development phase, and affords an orderly transition from research and component development to engineering (chart IV). It generally

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[6]US Dept of Defense Instruction 7720.13, Reporting of Current Research and Exploratory Development Effort at the Work Unit Level, 27 Jan. 1965, p. 3.

[7]Ad Hoc Working Group, op. cit., pp. 1-11, Tab Q.

lasts for about 2 to 2.5 years and overlaps the concept phase by 1 year. The definition phase systematically translates technological advances into total system design requirements. It is during this period that the requirement (QMR) is prepared and approved, the mission and performance envelopes are established, cost effectiveness studies are performed, tradeoff studies are completed, and the best technical approach is selected. In addition, a program change proposal (PCP) usually is submitted early in the phase as well as a preliminary TDP, to get planning approval in time (13 to 15 months required) to initiate engineering development in an orderly manner.[8] For projects meeting the requirements for contract definition, this phase acts as the contact formulation phase.[9]

The work performed in the definition phase falls entirely within the exploratory and advanced development categories of Program VI, Research and Development. It is here that the preliminary engineering, contract, and management planning are carried out to assure that management decision to proceed with, cancel, or change the development are made on a total cost and system basis. Performance specifications are drawn up as well as the tentative plan of development and production.

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[8]AMCP 11-2, op. cit., pp. 44-46.

[9]US Dept of Defense Directive 3200.9, Initiation of Engineering and Operational Systems Development, 1 Jul. 1965, p. 2 (referred to hereafter as DODD 3200.9).

Projects in this phase generally are justified by TDP's which are preliminary at the beginning of the phase and are revised and updated prior to entering the next phase of development. The plan for contract definition is required for projects costing over $25 million R&D funds or $100 million in production.[10]

This phase, although shown by the AMC model as costing 2-2.5 years, may last several years longer if higher headquarters approval is not obtained to proceed into the engineering development category. This is especially true of those complex projects bordering on the state-of-the-art in which the costs and technical risks are high. OSD may require system demonstration of the new system to see what technical approach should be approved. As a result many costly projects never get beyond this phase, especially if they provide only marginal improvement over existing systems. In addition, unless the projects can be shown to be superior to and cheaper than competing systems of the Navy or Air Force, they may never get program approval. The building block technology is not lost, since it is often used by other systems coming along at a later date. The projects that are approved then progress into the development phase.

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[10] _Ibid._, pp. 3-4.

DEVELOPMENT PHASE

The development phase immediately follows the definition phase in all cases, except when the contract definition process is conducted and overlaps the production phase when advanced production engineering (APE) is performed concurrently with development (chart IV). It is during the development phase that design, engineering, and testing are performed to come up with an end item which satisfies the QMR or SDR. The main product of research and development, and in many cases the only real product, is information that can be provided to a production organization for use in producing the item developed. The research and development information together with the data obtained from APE is used to make up the technical data package. This package is necessary for type classification and quantity procurement. The phase starts when a project is initiated in engineering development or operation systems development and ends when an item has been type classified as standard. In cases where an item is type classified limited production, the development phase may last several years longer.[11]

Work in the development phase consists entirely of effort programed in the engineering and operational systems development categories of Program VI, Research and Development. Most projects are carried in the engineering development category until type classified. However, if the force structure has been approved along

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[11] AMCP 11-2, op. cit., pp. 49-51.

with the organizational and doctrinal use and logistical plans, the project normally will be placed in the operational systems category. This, then, permits concurrent production planning and expenditure of procurement funds while development still is being carried out. Certain high priority projects may be placed directly into the operational systems development category without entering into engineering development.

Ideally, the development phase should last 4 years from the initiation of the project in engineering development until type classification as standard.[12] An item undergoing contract definition is supposed to spend 6 months in contract verification before proceeding on into development. Sometimes the decision is unfavorable and the project is cancelled or sent back for some more exploratory or advanced development work.[13]

Maintenance, organization, logistical, training, and doctrinal considerations must be integrated in the cycle concurrently with the development of a new system in order that the necessary personnel are trained and equipped to use the materiel properly when produced. Practically all these factors are keyed to the development cycle. If the development slips, then so do training and maintenance manuals, procurement, and organizational changes. Upon completion of development and testing, the item moves into the production phase.

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[12] US Dept of the Army, Army Regulations 705-5, p. 2.
[13] DODD 3200.9, op. cit., p. 10.

PRODUCTION PHASE

The production phase follows immediately after the development phase and may overlap it, if concurrent advanced production engineering (APE) is performed during development (chart IV). The phase is completed when the item no longer is being procured or when another item has been substituted in its place.

> The purpose of the production phase is to take the technical data package assembled during development and APE to produce, manufacture, rebuild, distribute, store, maintain while in storage, and to make engineering changes during the production period of major items of equipment required for operational issue or general service use, by the Army.[14]

The production functions are interrelated and dependent on results obtained during the development phase. For example, a slippage in type classification of 3 months may delay procurement by 6 months to 1 year, if the slippage occurs just before finalization of the Army Materiel Program (AMP).

The production phase in the AMC model lasts about 8 years. The time is dependent on the service life of the item and how rapidly technology changes. For example, the normal service life of a jeep is 6 years; a helicopter, 9 years; a barge, 30 years; and so on.[15] In general, it takes AMC nearly 2 years to progress from type classification to delivery of the first operational units to the field. This varies somewhat depending on the complexity of the

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[14] AMCP 11-2, op. cit., p. 60.

[15] US Dept of the Army, Army Materiel Plan (U) Fy 1963-70, Aircraft and related items, Vol. I, Part I, p. 16. CONFIDENTIAL.

equipment and the type of contract used to perform the necessary procurement.[16]

New items of equipment usually are programed to be bought over a 5-year time span. This permits orderly buildup of new equipment and gradual phaseout of obsolete items without having an excess amount of equipment wearing out at one time. It also permits orderly programing and scheduling of funds, facilities, and manpower without having large fluctuations in resource requirements.[17]

OPERATIONAL PHASE

The operational phase usually begins about 2 years after the go ahead is given for production and ends when the item or system has been declared obsolete and is eliminated from the Army inventory (chart IV). The duration of this phase varies greatly from system to system and with the commodity concerned. The cycle shown in the AMC model covers a time span of 13 years for an item having a service life of 10 years. This phase is characterized by supply, training, maintenance, and materiel readiness operations while the item is being used by operational units. Deficiencies in the equipment uncovered during field use are fed back into R&D and production agencies for modification of new or production materiel.[18]

Once an item is in the operational phase, it has no effect on leadtime except to provide operational data useful to the designer

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[16] Ibid., passim.
[17] AMCP 11-2, op. cit., p. 24.
[18] Ibid., p. 66.

in developing new systems. The operational phase is usually the most costly phase of the materiel life cycle, in that maintenance costs generally exceed the development and production costs by a factor of 3 to 20.[19]

DISPOSAL PHASE

The disposal phase begins when items or systems have been declared obsolete and no longer are suitable for use by the active Army (chart IV). It is completed when the item has been purged from the inventory. Initiation of development of a new end item usually commits the old item to obsolescence, for when an item is forecast for type classification, a recommended plan for phaseout of the old one must be developed. The disposal phase is shown to last 4 years, but it may be longer or shorter depending on the characteristics of the system and the circumstances involved.[20]

PHASE RELATIONSHIP

The phases enumerated above are interrelated, and different personnel are working on different areas of the work at any one time. The scientist in the concept phase working on basic research may work for many years and never get out of the concept phase of the research category of Program VI. His work continues on a stable-level-of-effort basis year in and year out until he proves

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[19] *Ibid.*, p. 16.
[20] *Ibid.*, p. 69.

or disproves some scientific fact or endeavor. Then, if this endeavor has some end item application, he may work additional years to see it developed into a new materiel system.

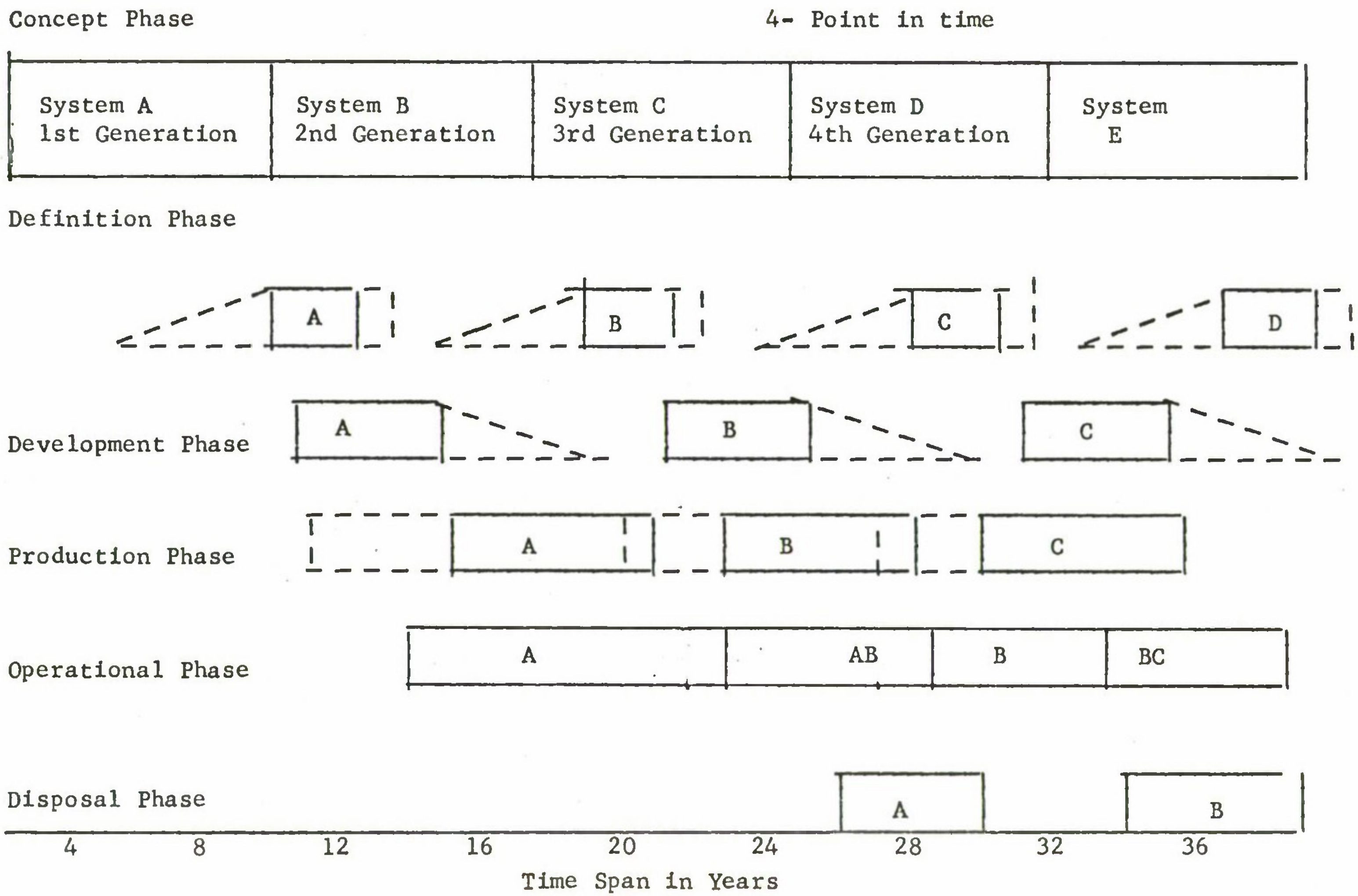
The development engineer, on the other hand, usually will be working through at least three phases. He starts with exploratory development with component development work, progresses to advanced development, and then, hopefully, into engineering development. Then, when he finishes one item, he usually will start the whole process over again on a related item. Thus, he may be employed for 3 years or more on component development prior to entering the definition phase where the components will become building blocks for a system undergoing systems demonstration (chart IV). Then, when the system is approved for engineering, he will spend about 4 years supervising development and testing. On completion of type classification, he may assist on engineering during production for as long as 5 years before being assigned to a new project.

The production engineer and maintenance personnel are working on the standard system, while the scientist and the designer are working on the next or third generation system.

One can see from Chart V that while research is being done on a future system (D), work is being done to define and initiate development on a new one (system C). At the same time, production is being carried out on the latest system type classified (system B) as standard A. There are two systems in operation; the

CHART V

PHASE RELATIONSHIP



new system (system B) and the obsolete (system A). Disposal action is being taken to get rid of the obsolete materiel (system A) in the inventory.

A careful examination of the chart shows that a new development project is initiated about every 9 years. Therefore, new technology and equipment is being fed into the cycle, even though the beginning and the end of a system may be 30 or more years.

The life cycle, when correlated with the combat developments concept program, appears as shown on chart VI. One can readily see that each of the Army's study projects provides guidance to the developing agencies regardless of the time frame involved. The type of guidance provided is shown for each period on the chart. To coordinate and to help manage the various steps of weapons systems development milestones are used.

MILESTONES

The AMC uses milestones in each phase of the life cycle as a basis on which to plan, direct, and control the individual life span of major weapon or equipment systems. Milestones provide a common yet flexible means to control, schedule, and report progress on projects as they move through the life cycle. By having standardized milestones with common definitions, it is much easier for managers to moniter and coordinate actions at all levels.[21]

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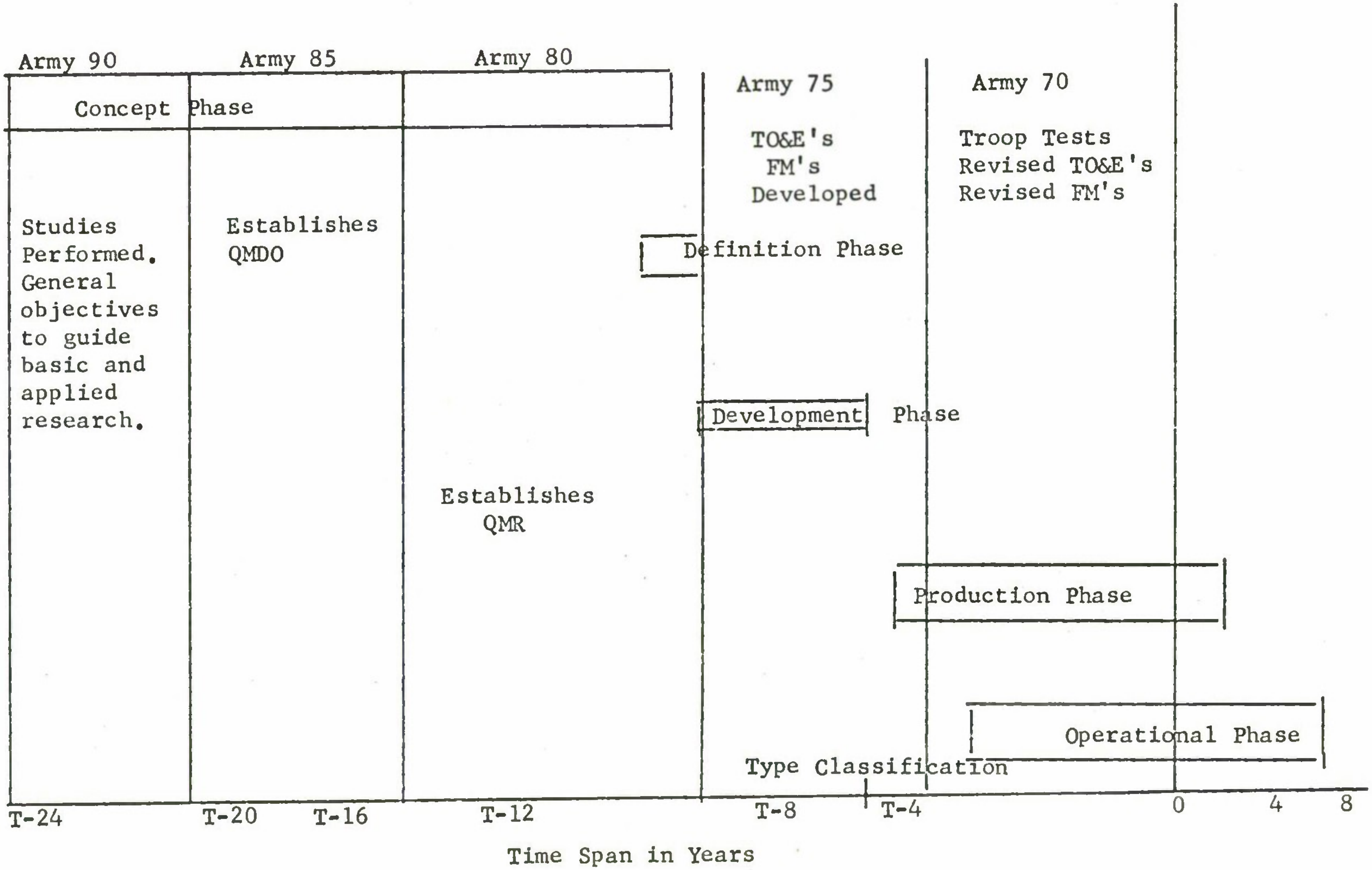
[21] US Army Materiel Command, AMC Milestones AMCR 11-27, Aug. 1965, p. 2 (referred to hereafter as AMCR 11-27).

CHART VI

RELATIONSHIP OF LIFE CYCLE TO
COMBAT DEVELOPMENTS PROGRAM



The number of milestones for any project will vary, both as to complexity and to the phase it is in. In general, as the cost goes up in terms of resources, more milestones will be used to report and control progress. Most of the milestones are associated with the development and production phases, for it is here that scheduling is critical and coordination requirements are greater.

AMC identifies four types of milestones for use in the materiel acquisition process. They are the (1) DA or OSD; (2) the major; (3) special; and (4) add on milestones. Each has its special use, and the information is utilized at different levels of management. Hence, DA milestones include those needed by the DA in its monitorship of a project. It may sometimes include major and special milestones as well.[22] Headquarters AMC usually has special requirements and may add additional milestones. Similarly, at lower echelons, more control points are added as necessary, although the information going from lower to higher headquarters is kept to a minimum commensurate with the higher headquarters particular requirements.

It is believed that the full implementation of milestones and configuration management will assist materially in reducing leadtime and cost overruns. Changes to the QMR or engineering changes will have to be fully evaluated to determine the overall effect prior to being implemented. This involves not only the developer (AMC), but also the trainer US Continental Army Command (CONARC) and (CDC).

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[22] Ibid.

Prior to this time, changes were made without regard to overall impact on the various projects.

CONFIGURATION MANAGEMENT

A recent management tool adapted by AMC to assist in coordinating and directing weapons and equipment systems is configuration management. It is used primarily in the development, production, and operational phases of the weapon systems acquisition process.

> Configuration management . . . is a system for recording the established military requirements for materiel; assuring that no changes affecting these requirements are made and that all other changes are reviewed for total impact and cost-effectiveness; and maintaining an adequate record of the requirements, changes, and hardware status throughout the life cycle of materiel.[23]

Configuration management is designed to provide top management with the necessary information from which it can make accurate and timely decisions and to provide a control system for design and engineering during both development and production.[24] It is too early to access the value of this new technique on the materiel development process, since it still is being placed into operation. It was adapted in August 1965 for use by all personnel concerned with the materiel acquisition process.

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[23] US Army Materiel Command, Configuration Management AMCR 11-26, p. 2.

[24] *Ibid.*, pp. 3-4.

CHAPTER 4

ANALYSIS

GENERAL

In analyzing the R&D materiel life cycle for leadtime reduction, primary emphasis has been placed on the definition, development, and production phases since they are the most critical in any new project. The concept phase includes many projects that are not end-item-oriented and, hence, never end up as identifiable projects during the later phases. The operational and disposal phases do not contribute to leadtime, since they occur after a new system has been developed and produced.

This analysis is based on a review of current regulations published by various agencies within the DOD, actual case histories of selected projects compiled by Headquarters AMC and the AMC Board, and 5 years practical experience in R&D at the policy and procedures level of the Chief of Engineers (1960-1962) and Headquarters AMC R&D (1962-1965).

REVIEW OF REGULATIONS

There is no precise definition of leadtime in Army regulations. Many state or imply that overall leadtime should be held to a minimum, yet, also state requirements such as cost, schedule, reliability, simplicity, transportability, testing, and cost reduction that tend to extend and delay the time until a new system can be placed in the

field. AR 11-25 does not specify when project initiation will begin but states that the development leadtime objective of the Army is 4 years or less from project initiation to first production rolloff.[1] The time from type classification to production rolloff alone requires nearly 2 years. Thus, this allows only 2 years for design, engineering, testing, and type classification. On the other hand, AR 705-5 specifies that the development leadtime objective of the Army is 4 years from project initiation to type classification as standard. In this regulation, project initiation is taken to mean the date that the AMC technical committee records or approves the project for development in the engineering development or operations system development category of Program VI, Research and Development.[2] If development leadtime objective is valid at 4 years, then the overall leadtime objective from concept to first production rolloff would be a minimum of 8 years, allowing 2 years for the definition phase and 2 years after type classification for production leadtime. This is recognized to be realistic in today's environment for the model used by AMC. This would mean a 6 year gap in the use of advances in the state-of-the-art, since changes to engineering development contracts using fixed-price or incentive contracts would defeat the basic idea of using them in the first place.

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[1] US Dept of the Army, Army Regulation 11-25, 27 Sep. 1961, pp. 1-2.

[2] US Dept of the Army, Army Regulation 705-5, 14 Jan. 1963, p. 2 (referred to hereafter as AR 705-5).

Changes to contracts once awarded upset the incentive arrangements and make government administration more difficult and expensive.[3]

In summary, the overall leadtime objective of the Army and DOD should not exceed 8 years in the definition, development, and production phases, if the Army is to be a leader in the world of today. The subsequent discussions elaborate on areas where this leadtime objective can be achieved, if appropriate measures are taken.

REQUIREMENTS

An area of controversy is the requirement to have an approved requirements document to support projects in the development phase before beginning engineering development. Projects are then held up in the definition phase until agreement can be obtained on a valid requirements document, such as QMR or a SDR. Since it takes some 8 to 18 months on the average to prepare, staff, and obtain DA approval of requirements documents, this may delay or add to the leadtime required to develop a new item. The QMR or SDR is an Army imposed requirement and is not required at OSD level.[4] DDR&E is satisfied with a general statement or mission proposed for the system that can be included in the TDP. Thus, one source of early delay could be eliminated by discontinuing the requirement for an

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[3] US Army Materiel Command, The R&D Life Cycle, pp. 32-34.
[4] US Dept of the Army, Ad Hoc Working Group, Final Report on Materiel Requirements and Development Procedures, 15 Apr. 1965, pp. 44-52. FOR OFFICIAL USE ONLY.

approved QMR and SDR, if it delays project initiation and sufficient technical and cost data are available, on which to make a sound decision to proceed without it.

NASA and the AEC have taken the approach that developers should carry promising developments through the demonstration stage. This approach provides a potential user with a clear cut basis on which to make an intelligent decision with respect to specific missions. Meaningful cost analyses are made possible only through the practical demonstration of technology, and the elimination of stop-and-go project management can cut waste in expensive technology.[5] In addition, it probably would cut overall leadtime.

Another frequent complaint about the Army's requirement documentation system is that it requires too much time to prepare. It has been stated that it takes 8 to 18 months just to prepare and staff a new requirements document. A lot of this time could be eliminated, if the QMR was structured to be limited to stating the requirement as to what was wanted and leave the how of the requirement to the developer. This would give the developer and the contractor more flexibility in developing a new system and would make maximum use of industry's incentives to produce a quality product containing the desired characteristics.

Timely and adequate coordination among CDC, AMC, and Department of the Army (DA) should prevent any project being held up because of a lack of a requirement.

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[5]James T. Ramey, "How Can We Get Off The Requirements Merry-Go-Round," Air Force Magazine and Space Digest, Vol. 47, Jul. 1964, pp. 81-2.

Altogether the Army has too many requirements documents to be supported by the existing R&D program. There are now some 185 QMDO's, 285 QMR's, and 110 SDR's that are approved for development projects.[6] These cannot be supported adequately by an Army program of about $1.5 billion.[7] This is especially true when you consider that one QMR on the Ballistic Missile project takes approximately one third of the money allotted to R&D for the Army.[8] It is realized that some projects may support one or more QMDO's, QMR's, and SDR's, but still there are too many.

It is the goal of CDC to have 25 percent of the requirements listed as priority 1; 25 percent as priority 2; and 50 percent as priority 3.[9] Hence, if priority is given to priority one projects at the expense of lower priority projects, the lower priority projects will be extended and will be subject to stop and go development. This causes disruption of personnel and inadequate use of critical facilities when performed on a year to year basis. It is believed that a thorough screening of the existing approved requirements documents is required and an effort should be made to reduce them at least by half. This would permit more optimum funding on critical projects and permit adequate component development.

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[6] William W. Dick, Jr., "A Promising Future in Military R&D," Army, Vol. 15, No. 16, Nov. 1965, p. 54.

[7] U.S. Bureau of the Budget, The Budget of the U.S. Government for Fiscal Year Ending June 30, 1967, p. 330.

[8] US Dept of the Army, Office of the Chief of Research and Development, Project Listing, R&D FY 1965-1971 Program (U), p. 32, CONFIDENTIAL.

[9] US Dept of the Army, Ad Hoc Working Group, Final Report on Materiel Requirements and Development Procedures, pp. 26-30. FOR OFFICIAL USE ONLY.

PROJECT REORIENTATION

A complaint about frequently changing or reorientation of development projects is also heard. This may be caused by several factors, such as changes in the QMR, state-of-the-art advances, overly optimistic planning, technological difficulties, or excessive cost overruns. These difficulties should not occur in the current environment, if the system development is essentially completed prior to entering the development phase. Two prerequisites to entering engineering development are the OSD requirements that a project should be primarily one of engineering and that all the technical risks be identified. This also requires a large component development program to have the necessary technology in many key fields of endeavor available to support new weapon systems on short notice. Whenever a new system requires technological breakthroughs in basic and applied research, it is not ready to be placed in the development phase.

Approximately 68 percent of the DOD R&D funds will be spent on development, only 20 percent will be spent on applied research and 12 percent on basic research.[10] Hence, only about 20 percent of the DOD R&D funds is spent on component development. This is believed to be insufficient to maintain the necessary building block technology from which new systems can be built.

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[10] Victor J. Danilov, "$23 Billion for Research," Industrial Research, Vol. 8, No. 1, Jan. 1966, p. 32.

Recently, there has been considerable and growing criticism of mission-oriented research and development. In fact, Congress has established the Research and Technical Programs Subcommittee of the House Committee on Government operations to determine whether the nation's scientific resources are being used economically to achieve vital national goals.[11]

An examination of the case studies selected for verification of the proposed reduction of leadtime shows that all of them were re-oriented at least once during the development period.[12]

To reduce project reorientation, several steps can be taken to assist the development agencies. They are:

1. Reduce number of requirement documents.

2. Revalidate the QMR/SDR at each in-process review. (This would eliminate projects proceeding the type classification before discovering no requirement exists.)

3. Keep information in the QMR limited primarily to the performance characteristics required.

4. Approve the QMR and the TDP at about the same time.

5. Require an early decision on production. (One year after decision to initiate production.) This decision requires a further validation of the QMR and is an indicator that the Army really needs the new item.

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[11] Ibid., p. 46.

[12] US Army Materiel Command Board, Control of Leadtime Project AMCB 2-64, 30 Jun. 1965, p. 12 (referred to hereafter as AMCB 2-64). FOR OFFICIAL USE ONLY.

TESTING

An area that takes up about one fourth (1 year) of the development leadtime is testing by an independent agency.[13] In AMC this is performed by the Test and Evaluation Command (TECOM). There are certain tests that aren't performed by TECOM, such as engineer design testing, R&D prototype acceptance tests, surveillance tests, and user tests. The tests performed by TECOM consist primarily of the confirmatory, check, engineer and service tests. Generally engineer and service tests are conducted concurrently to cut down on the test time.

An AMC Board study calculated on the basis of its review of eight case studies that testing, evaluation, and completion of the test reports requires an average of 1 year and 5 months or 27 percent of the development leadtime. This is a substantial reduction from the Technical Services' experience for these functions which was 35 percent of the development leadtime.[14] To meet the objective of 4 years in development requires a maximum allocation of 1 year for testing. To do this requires:

a. Early coordination between the developer and the tester in obtaining a valid coordinated test plan.

b. Provision of sufficient prototypes with adequate repair parts for testing.

c. Elimination of long R&D acceptance testing by the developer before release to the tester. (See discussion on page 57.)

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[13] US Dept of the Army, Army Regulation 70-10, p. 4.
[14] AMCB 2-64, op. cit., p. 33.

CASE STUDY OF SELECTED PROJECTS

In selecting projects to study the leadtime problem, it was necessary to take those on which adequate data could be obtained. Many projects were considered and discarded because of insufficient information. As a result, it was necessary to compromise and select some that were initiated some time ago while under control of the technical services and others that were started after AMC was organized. In addition, it was necessary to select at least one or more projects from each of AMC's subordinate commands. The case studies selected were those submitted by the separate commands in response to an AMC letter requesting representative project case histories to be used in determining leadtimes for various milestones in the AMC life cycle.[15]

Fifteen projects were selected for detailed analysis as follows:

	Project Title	Developer	Status
1.	Improved HAWK	Missile Command	Still in development
2.	SERGEANT Missile System	Missile Command	In limited production
3.	Truck, cargo, 5 ton, 8x8, XM656	Mobility	In development
4.	Pershing	Missile Command	Limited production
5.	Gun, self propelled, full tracked, 175 MM, T235 (M107)	Weapons Command	In production

[15]William B. Sussmann, Letter to AMC Subordinate Commands, 24 Sep. 1965.

	Project Title	Developer	Status
6.	Truck, cargo, 1¼ ton, 6x6, XM561	Mobility Command	In development
7.	Howitzer, light, towed, 105MM, M102	Weapons Command	In development
8.	Range finder, laser XM23	Weapons Command	In development
9.	Armament subsystem, helicopter, 40MM grenade launcher, M5	Weapons Command	In development
10.	Radio Set AN/PRC-62	Electronics Command	In development
11.	Signal generator AN/URM103	Electronics Command	In development
12.	Cache system	Mobility Command	In development
13.	Airfield specialized trailer system	Mobility Command	In development
14.	Cartridge, 105MM, beehive, XM546 w/fuze, MT, XM563 (HOW)	Munitions Command	In development
15.	M190 warhead section (chemical-biological warhead for HONEST JOHN rocket)	Munitions Command	In development

In addition, selected information was obtained from the case studies prepared by the US Army Command Board on the following eight systems or items:[16]

1. REDEYE Missile System
2. Lance Weapons System
3. Tube launched optically guided, wire controlled (TOW) Missile System

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[16]AMCB 2-26, _op. cit_., p. 9.

4. Visual airborne target locator system (AN/UVS-1)

5. Trucks, logistical, high mobility (GOER), 4x4, 8TM Family.

6. 107MM XM95 motar system

7. Air supported aviation maintenance tent, medium

8. Auto deployable face mask

In using the case studies, certain key milestones were selected to see where excessive time was being spent primarily during the development phase. The milestones selected are shown on chart VII. Not all of the case studies had measureable milestones. It is realized that the samples selected may not be sufficient to draw valid conclusions, but they can be used to identify areas where possible improvements can be made.

The first area has to do with initiating new projects. Most of the projects were reoriented at least once sometime during the development phase either because of no valid requirement (in the case of the Pershing Missile system for a 500 mile missile) or because of a lack of funds (as in the cache systems). The definition phase permits 2 years to define the project, get a valid requirement approved (QMR), program the necessary funds, perform the necessary cost/effectiveness studies, conduct tradeoff analyses, prepare a technical development plan including the coordinated test plan, identify the best technical risks involved, and obtain program approval. Naturally many of these activities have to be performed concurrently. Ideally, a new project should be initiated shortly after approval of the QMR to take advantage of the latest technical advances and to cut leadtime to a

CHART VII

CASE STUDY MILESTONE ANALYSIS

Milestone	Projects Analyzed	Maximum Time Days (Item)	Minimum Time Days (Item)	Average Days	Mean Days	Target[1] Time Days
Initiate Project	11	2220 (Pershing)	120 Signal Generator	537	300	90
D&F Approval	9	164 (Cache System)	30 (Gun - M107)	80	60	68
IPR Technical Characteristics	10	371 (Cache System)	50 (Howitzer M102)	143	123	90
IPR Engineering Concepts	9	138 (Pershing)	40 (Gun - M107)	84	85	90
IPR Design Characteristics	10	391 (Truck XM561)	60 (Armament Helicopter 40MM)	158	129	90
IPR Prototype Systems Review	9	523 (Cache System)	60 (M190 War-head Section)	184	138	90
IPR Service Test	9	390 (Gun - M107)	35 Radio (AN/PRC-62)	152	134	90
Award Development Contract	11	1202 (Cache System)	38 (Improved Hawk)	391	239	150
Advanced Production Engineering	8	2603 (Gun - M107)	160 (Generator AN/URM-103)	1065	660	810

[1]Extracted from AMCP 11-2

Milestone	Projects Analyzed	Maximum Time Days (Item)	Minimum Time Days (Item)	Average Days	Mean Days	Target[1] Time Days
Engineer and Service Test	12	1200 (Sergeant)	130 (Gun - M107)	348	185	90
Engineer and Service Test Reports	9	775 (Truck - XM561)	35 (Gun - M107)	242	120	90
Type Classification	13	270 Generator AN/URM-103	114 (M190 War-head)	173	156	120
R&D Acceptance Testing	10	2678 (Truck XM561)	8 (Cache System)	516	301	30
Training Aids Development	5	890 (Gun - M107)	75 (Improved Hawk)	639	780	900
5 Year New Equipment Training Plan	5	1440 (Pershing)	87 (Improved Hawk)	425	220	200
QMR Approval	3	2010 (Pershing)	300 Radio AN/PRC-62	930	480	400

[1]Extracted from AMCP 11-2

minimum. In general, good planning permits new projects to be started in an orderly and timely manner without the stop and start procedures so recognizable in the projects analyzed.

A second area in need of critical examination is the need for five in-process reviews (IPR). AR 705-5 specifies that all are necessary and mandatory and that additional ones may be held, if desired.[17] In none of the projects considered were all of them held. Two or more were omitted in at least six of the projects. If all are held, it takes 721 days alone just to conduct the in-process reviews. This is nearly half the time allotted to the development phase. In addition, the first four (technical characteristics, engineering concepts, design characteristics, and prototype systems) in-process reviews are scheduled to be held in the first year and a half of the development phase. At least one and perhaps two of the reviews can be eliminated without any degradation of quality. One properly conducted in-process review per year should be sufficient to guide the developer during the development phase. This is especially true if a valid and complete QMR exists, a coordinated test plan and a 5-year new equipment plan have been prepared, and development is being performed out-of-house on an incentive contract. Perhaps additional reviews might be required for in-house development. Deletion of two in-process reviews could save at least 6 to 8 months of leadtime. Also, the QMR should be validated at each in-process

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[17] AR 705-5, op. cit., pp. 13-14.

review to prevent projects progressing to type classification before the USA Combat Developments Command decides that no requirement exists, as occurred in the case of the GOER.[18]

A third way in which leadtime can be reduced is to use multi-year contracts to cut down on contract award time and the D&F processing time. As it is now, a new D&F is required, and a new contract is needed for each year's effort. Timely submission of D&F's and expedited processing should eliminate any loss of leadtime due to lack of authority to negotiate, as occurred in the cache system. The biggest gain in leadtime appears to be in awarding development contracts on a complete program package deal, like the Air Force CV-5A program. Here the developer also becomes the producer for the first production buy. This method is not possible on some projects but a valid concept for many. The first production buy would be the minimum necessary to prove out the technical data package. This would eliminate timely and costly delays in awarding contracts and reorienting contractors and would assure that the product developed would be the same as that produced. Formal advertising or competitive procurement could be used on the second and succeeding production buys. This method of development and procurement would reduce at least 1-1.5 years leadtime on the average without loss of quality or reliability. It would eliminate 6 months on the award of the ET/ST contract, 5 months for the production

[18]AMCB 2-64, op. cit., pp. 12-13.

contract, excessive times in R&D acceptance testing (Truck, 5-XM-2,678 days), and possibly 2 to 3 months on initiating advanced production engineering.

A fourth way to reduce leadtime is to make an early decision on production. Ideally, a decision to develop almost always should be followed shortly by a decision to buy. This is necessary to obtain advanced production engineering and production funds in a timely manner. As it is now, it takes some 8 months to obtain a basis of issue, which is necessary before quantitative requirements can be computed. This time added to the time required for programing and budgeting the necessary funds makes it mandatory that an early decision be made to obtain advanced production funds when needed--about 2 years prior to type classification. Generally, this is not a problem for major projects or systems, but marginal improvements are almost always delayed awaiting decisions to go ahead. Reducing the number of QMR's and SDR's would eliminate many of the problems in this area.

A fifth way to improve is to place all projects in the development phase under a project manager or commodity manager to have one individual responsible for assuring that all necessary actions are taken in a timely manner. He should be appointed in the definition phase and follow the project until "it is fielded." This requires some one to develop an overall master plan which will be time phased to include all aspects of development, training, testing, facilities planning, procurement, and maintenance. Many of these have to be

performed concurrently but are keyed to the development schedule. Having one man responsible in each organization would help identify and coordinate actions. In the past many decisions made by functional managers based on program funding in the RDT&E, PEMA, and QM&A budgets were made without regard to the impact caused on individual projects. As a result, some were delayed because of a lack of funds, facilities, or training personnel. Examples illustrating these delays include the cache system, the 5-ton cargo truck, and the airfield specialized trailer system.

A sixth way to decrease leadtime would be to eliminate the testing performed by the developer prior to release to TECM for engineer and service testing. An analysis of selected projects shows that the 5-ton cargo truck was held up for 2,678 days because of R&D acceptance testing prior to release to TECM. An average of 516 days was used in acceptance testing for those projects analyzed. This is entirely too long and should not exceed 30 days at most. It should be long enough to assure that the contractor has performed as required by his contract and no longer. Acceptance testing performed by the developer duplicates most of the tests performed in the engineer test.

Finally, the last area in need of improvement is the type classification of an item as standard.[19] Some 173 days, on the

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[19]US Dept of the Army, <u>Army Regulation 700-20</u>, 25 Jul. 1963, p. 1.

average, were required to type classify an item. This can be reduced nearly 2 months if the administrative procedures can be streamlined by using informal coordination between AMC and CDC and additional concurrent rather than sequential approval channels, as now proposed by AMC.[20]

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[20]Mason B. Larwood, Research and Development Leadtime Study, 18 Jan. 1965, p. 6.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

From the foregoing analysis it is concluded that the impact of science and technology on new weapons systems and the Army's capability to perform its assigned missions is very great. How well the Army can maintain its leadership role in the world will depend, to a large extent, on how effective its research and development organization reacts to change-of-the-art advances and how soon these advances can be applied to new systems.

Consistent with efficiency, economy, and effectiveness it is recommended that:

1. The total leadtime objective from concept to first production rolloff be established as not to exceed 8 years. This permits 2 years for the definition phase, 4 years for development, and 2 years for production leadtime.

2. The number of mandatory in-process reviews be reduced from five to a maximum of four with three being the most desirable.

3. Early decisions (within 1 year after project initiation) on production be required.

4. The number of requirements documents be examined and reduced by approximately half.

5. Complete package contracts be awarded on selected projects, for which firm requirements can be established at the time of project initiation.

6. Project or commodity managers be appointed for all projects in the definition, development, and production phases to coordinate and manage them from concept to employment in the field.

7. Planning, coordination, and administrative procedures be strengthened to reduce review, justifications, reporting, and reorientation to a minimum.

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